logical problems of the first importance is pointed out by Sir Napier Shaw in the preface, and we trust that the wished-for extension of stations into wide areas not yet represented in the *Réseau Mondial* will materialise before long.

The work concludes with an excellent bibliography of the 160 memoirs consulted by the author. There are numerous illustrations, including plates showing the seasonal isotherms, and isopleths for four typical stations. This book will remain a standard work of reference on Brazilian meteorology for many years to come. R. C. M.

LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

The Radiation of the Stars.

THE law $T \propto M^{1\frac{1}{2}}\rho^{\frac{1}{6}}$ given by Prof. Eddington in NATURE of June 14 is so neat that one feels reluctance to cast any doubt on it, but since it is notoriously difficult to destroy a scientific error which has once obtained a fair start, I feel that whatever is to be said against the law ought to be said now.

The law is derived from Prof. Eddington's supposed equation, radiation-pressure = gravity. It must first be noticed that the two sides of this equation are of different physical dimensions ($ML^{-1}T^{-2}$ and LT^{-2} respectively), so that neither the arguments on which the equation is based nor the laws derived from it can carry much conviction. If p_G and p_R denote gas-pressure and radiation-pressure, the true equation of equilibrium is

$$\frac{\partial}{\partial r}(p_G+p_R) = -\rho g,$$

g being gravity, and when p_G is neglected in comparison with p_R, g does not become equal to p_R, but to $-\frac{1}{\rho}\frac{\partial p_R}{\partial r}$.

It is true that in his original paper on this subject (*M.N.*, November, 1916) Prof. Eddington obtains a relation of the form $p_R = Rg$, where R is a constant, but this equation is not based on the physical conceptions put forward in the article in NATURE. The outward flow of radiation from a star of radius r and effective temperature T is, of course, $4\pi r^2 \times \sigma T^4$. Where does the energy of this radiation come from? Prof. Eddington assumes that it is a transformation of radio-active energy, initially emitted at a uniform rate $4\pi\epsilon$ per unit mass throughout the whole star. The star is assumed to be in a steady state, so that the rate of generation of energy, $4\pi M\epsilon$, is equal to the rate of emission $4\pi r^2\sigma T^4$, whence $\sigma T^4 = M\epsilon/r^2$.

This equation is of the form $p_R = Rg$, and on eliminating r by means of the relation $M = \frac{4}{3}\pi\rho r^3$, we find that $T \propto M^{1\frac{1}{2}}\rho^{\frac{1}{6}}$. (Prof. Eddington's complicated analysis, boiled down to its essentials, comes merely to this.) But it now appears that the supposed law is not, as might be thought from a casual reading of the article in NATURE, a deduction from already known laws of Nature; it is a transformation of the very special assumptions that all stellar matter is equally and uniformly radio-active, and that this radio-activity is the origin of all the energy radiated from a star.

The second supposed law, that the total emission of radiation from a star depends only on its mass, is a still more thinly veiled repetition of the same assumptions. The radiation is *assumed* to be $4\pi M\epsilon$, and ϵ is assumed to be a universal constant. When these assumptions have been made, it is scarcely worth announcing as a new law that the radiation depends only on M.

I venture to think that few physicists will be ready to accept these assumptions; in any case it is important that they should be clearly stated. It may be remarked that if the assumptions are true for giant stars they might be expected to be equally true for dwarf; they lead, however, to the laws given by Prof. Eddington, such as that of absolute brightness depending only on mass, which are palpably untrue for dwarf stars. J. H. JEANS.

London, June 16.

MR. JEANS's criticism of the dimensions of my equation, "radiation-pressure = gravity," is clearly only a verbal matter. It may be preferable to expand the sentence so as to read, "force on material due to radiation-pressure = force on material due to gravity." But statements that radiation-pressure is x times gravity have been commonly made in connection with the theory of the repulsion of comets' tails, and I thought the reader would have no difficulty in interpreting my statement in the same sense.

The rest of Mr. Jeans's letter is based on a misconception. He states that I assume ϵ (the rate of liberation of energy per unit mass) to be a universal constant; that is not the case, and consequently his account of the mode in which my principal results arise is erroneous. My results are not "a transformation of the very special assumptions that all stellar matter is equally and uniformly radio-active. . . ."

I should be glad to take the opportunity of correcting a misprint in the article: p. 309, col. 2, l. 18 from bottom, *for* $M\rho^{\frac{2}{3}}$ *read* $M^{\frac{1}{3}}\rho^{\frac{2}{3}}$. A. S. EDDINGTON.

Cambridge, June 19.

Protection from Glare.

EFFICIENT protection of the eyes from glare is a subject of considerable importance at the present time, but unfortunately a great deal of misconception has arisen in regard to it. Most glare protectors are designed for conditions of unusually strong illumination; generally speaking, for daylight. Many industrial operations also demand the use of light filters. We will deal first with the problem of protection in sunlight.

A great deal of experimental work has been done recently on the physiological effects of ultra-violet radiation in the eye, a quartz-mercury lamp being used as a source, which is especially rich in its emission of the shorter wave-lengths. The results, unquestionable and undoubted, are that with long-continued exposure serious harm may result from the absorption of these shorter waves by the refracting media of the eye, but with low intensities of radiation regular exposures produce no permanent effect. Turning now to the effects of daylight on the eyes, we recognise that few cases occur in which the symptoms point directly to the influence of ultra-violet light as distinct from the effects of ordinary strong illumination; but the problem of nerve strain arising from glare is ever present.

Quite low intensities of light will produce glare

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when the eye is unadapted. The light from a gas lamp, blinding to an eye accustomed to darkness, appears feeble when viewed in full sunlight; yet its intensity of ultra-violet radiation is unchanged. Snow blindness may be caused on dull days, presumably owing to the inability of the upper part of the retina to adapt itself to the unaccustomed light from the ground. Dr. E. K. Martin[1] could detect no absorption by the refracting media of the eye in the visible spectrum, but he found that in the ultra-violet absorption begins at about 0·38 μ, and becomes complete for 0·35 μ and shorter wave-lengths. As the solar spectrum stops short at 0·29 μ (owing to the absorption of the atmosphere), we see that there is a short region from 0·35 μ to 0·29 μ, which may be absorbed and produce some physiological action. Therefore in cases where considerable sunlight or skylight must enter the eye, it is a good precaution to use a filter which will stop these ultra-violet rays, but at the same time it must be remembered that the main symptoms known as glare are not due to ultra-violet light at all, but simply to an illumination too intense for an unadapted retina.

To the normal eye the maximum luminosity in the solar spectrum lies in the region near the yellow. A great many filters now being supplied for anti-glare purposes are of a yellowish colour. They transmit 80 per cent. or so of the red, yellow, and green, and absorb the violet and ultra-violet fairly completely. It would seem at first sight as if such filters were very desirable to eliminate possibly harmful rays, and to reduce slightly the brightness of transmitted light. On using the screen, however, the apparent brightness of most objects seems to be increased, and glare is as evident as before. The phenomenon of adaptation is not yet fully understood, but we may refer in this connection to the work of Broca and Sulzer,[2] who found, in measuring the growth of visual sensation with time, and using various colours, that in every case there is an overshooting of sensation beyond its final value. With blue light the maximum sensation is at least five times, and with white light twice, the final value. If, then, the removal of the shorter wave-lengths interferes with adaptation, the apparent increase of brightness when using a yellow filter is explained. Obviously as an anti-glare glass the screen is worse than useless. This does not apply to the greenish glasses which actually reduce the apparent luminosity. In passing, it may be noted that a coloured filter of this nature is often useful for increasing contrast, eliminating blue light from haze, and increasing visual acuity. 'Amber' and 'red' filters are sometimes used. These generally absorb the green and blue parts of the spectrum, transmission again beginning in the violet. If fairly deep in colour they effectually stop glare, and may be exceedingly useful for special contrast work.

Neutral-tinted glasses have a comparatively uniform transmission over the whole spectrum. The use of such filters in practice immediately reduces any glare, and a proper balance of adaptation is established. It is curious to note in this connection that many of these neutral-tinted glasses, when about 1 mm. thick, transmit the ultra-violet from 0·39 μ to 0·32 μ almost as well as ordinary glass. They have often a slight increase of transmission in the green, and in the extreme red and infra-red they again show little absorption beyond that expected from glass of equivalent thickness. Light transmitted by a bundle of such glasses is found to consist of the extreme red, a little green, and the extreme violet; the sky, viewed through the bundle, appears of a deep purple colour.

Intense infra-red radiation also seems to produce well-marked effects on the eyes when exposure is regular and long-continued, but here again the amount ordinarily received by an eye exposed to daylight appears to be incapable of causing harm. It is uncertain how much (if any) of the discomfort of glare from the ground experienced in bright sunshine is due to the action of these rays. A correspondent of Sir W. Crookes describes the effect produced by spectacles of a glass containing ferrous iron, and absorbing the infra-red, as producing a marked cooling effect on the vision. This sensation may, of course, be merely the result of the relief from glare which the blue-green tint of the glass would secure. Manifestly, however, in circumstances where it may be necessary to look directly at or near the sun, an efficient filter is desirable to reduce intensity in all parts of the spectrum.

Some glasses show marked absorption in the infra-red in the neighbourhood of 1μ, notably those containing ferrous iron, cupric oxide, or ferric iron and cobalt together; these are blue to blue-green in colour. Interesting substitutes are metallic films on glass, suitably protected, which, for the most trying conditions, should make ideal glare glasses. As most of the radiation would be reflected, the glasses would tend to keep cool.

The problems arising in industrial work are relatively simple. For dealing with arc lamps, and sources extremely rich in ultra-violet light, dark green or brown-green glasses will be most suitable. For welding operations efficient protection from ultra-violet, visible light, and infra-red is important, as in this case it is necessary to watch the source of light intently. It is important also to select a filter which will not greatly distort the colour of the emitted light, as temperatures are judged in this way. A fairly dark neutral glass of good thickness will generally answer all practical purposes, but a highly efficient protector could be made by depositing a silver film of suitable thickness on a plate of heavy lead glass. This would be, as previously suggested, very effective in reflecting the heat rays, but the film would have to be protected.

A gold film can be made to transmit green light while reflecting almost all other radiations. Spectacles of this nature could be used with great advantage if it were necessary to work close to molten metal, or in many other circumstances.

It is hoped that this short summary of the subject may be of use to those dealing with problems in this connection. An extended series of tests on certain filters has been made by the present writer, and the results are now in course of publication in the Proceedings of the Optical Society. Filters for various purposes can thus be chosen, but their most important test will be their efficiency in actual use.

L. C. MARTIN.

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[1] Proc. Roy. Soc., B., lxxxv., p. 319.

[2] *Compt. rend.*, cxxxvii., 1903.

Electric Discharge from Scythe.

IN reference to Mr. Pannell's observations recorded in NATURE of June 21 (p. 324), Mr. William Wilson more than a hundred years ago discovered that when dry wood is chipped with a knife the chips and knife become oppositely electrified.

There is no need of darkness to test the phenomenon in the case of dry grass cutting with the scythe. An ordinary gold-leaf electroscope held in the mower's hand, and having a wire attachment with the metal of the scythe, would scarcely fail to give indications if the electrification is actually sufficient to produce disruptive discharges.

CHARLES E. BENHAM.

Colchester, June 23.

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